Black-Hole Interiors, Evaporation, and Observables in the Grand Unified Field Theory of Asymmetry

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Abstract

We present the first quantitative treatment of black-hole structure and evaporation within the Grand Unified Field Theory of Asymmetry (GUFT). Spacetime emerges from the Dark-Energy Quantum Field (DEQF); curvature is encoded by the Graviton Quantum Field (GQF) whose virtual excitations saturate at the Planck scale. We: (i) derive a static, spherically symmetric black-hole solution with a finite-density DEQF core that replaces the classical singularity; (ii) obtain a modified Tolman–Oppenheimer–Volkoff (TOV) equation including virtual-graviton pressure; (iii) compute the GUFT-corrected Hawking temperature and entropy; (iv) calculate late-stage evaporation spectra and establish observational signatures—gamma-ray bursts and gravitational-wave echoes—that differentiate GUFT from semiclassical GR.

1 Introduction

Classical General Relativity (GR) predicts curvature singularities hidden by event horizons. Quantum considerations (Hawking radiation) restore dynamics but not the information budget. In GUFT, spacetime is a condensate phase of the DEQF, and graviton modes saturate as $k \to k_{\mathrm{P}}$, supplying an effective pressure that halts collapse before the singularity forms. Below we formalise this picture.

2 Effective Stress–Energy of Virtual Gravitons

For a static, isotropic configuration we adopt

$$T_{\mu}^{\ \nu}(\mathrm{vg}) = \mathrm{diag}\big(-\rho_{\mathrm{vg}}(r),\, p_{\mathrm{vg}}(r),\, p_{\mathrm{vg}}(r),\, p_{\mathrm{vg}}(r)\big), \quad \rho_{\mathrm{vg}}(r) = \frac{\alpha\,\hbar}{8\pi G r^{2}}, \tag{1}$$

with $p_{\mathrm{vg}} = \rho_{\mathrm{vg}}/3$ for relativistic virtual modes. Near $r \to 0$ saturation limits the energy density to $\rho_{\max} = \hbar/(8\pi G \ell_{\mathrm{P}}^{2})$.

3 Modified TOV Equation

Write the metric

$$ds^{2} = -e^{2\phi(r)}dt^{2} + \big(1 - 2Gm(r)/r\big)^{-1}dr^{2} + r^{2}d\Omega^{2}. \tag{2}$$

Including baryonic matter (ρ_b) and $T_\mu^{\ \nu}(\mathrm{vg})$ the TOV equation becomes

$$\frac{dp_{\rm tot}}{dr} = -\frac{G\big[\rho_{\rm tot} + p_{\rm tot}\big]\big[m(r) + 4\pi r^3 p_{\rm tot}\big]}{r^2\big(1 - 2Gm(r)/r\big)}, \tag{3}$$

where $\rho_{\rm tot} = \rho_b + \rho_{\rm vg}$ and similarly for $p_{\rm tot}$. Integrating inward, collapse halts at r_c defined by $\rho_{\rm vg}(r_c) = \rho_{\rm max}$, yielding a core mass $m_c \approx (4\pi/3) r_c^3 \rho_{\rm max}$.

4 Horizon and Core Structure

Outside r_c the metric matches Schwarzschild with ADM mass M. Inside, the line element (2) remains finite; curvature invariants satisfy R, $R_{\mu\nu\rho\sigma}R^{\mu\nu\rho\sigma} < \ell_{\rm P}^{-4}$, eliminating singularities.

5 GUFT-Corrected Hawking Radiation

Mode saturation modifies the grey-body factors and temperature:

$$T_{\rm H}^{\rm GUFT} = \frac{\hbar c^3}{8\pi G M}\left(1 + \beta\frac{\ell_{\rm P}^2}{r_{\rm s}^2}\right)^{-1}, \qquad r_{\rm s} = 2GM/c^2, \tag{4}$$

with $\beta \sim \mathcal{O}(1)$. Entropy becomes $S = \frac{A}{4\ell_{\rm P}^2} - \gamma \ln(A/\ell_{\rm P}^2)$ ($\gamma > 0$), reflecting fewer high-k modes.

6 Late-Stage Evaporation and Remnants

Evaporation ceases when $M \to M_{\rm P}/\sqrt{\beta}$, leaving an extremal DEQF core or an explosive re-absorption burst releasing $E_{\rm burst} \sim 10^{19}$GeV photons and gravitons. Such bursts could manifest as ultra-short gamma-ray events; GW echoes may follow from core oscillations.

7 Observational Signatures

- **Gamma-ray bursts**: millisecond TeV–EeV flashes from primordial black-hole endpoints.
- **Gravitational-wave echoes**: post-merger ringdown deviations at frequencies $\gtrsim$kHz.
- **Shadow size**: Event-horizon-telescope images of super-massive BHs deviate by $\lesssim 1\%$ from GR.

8 Conclusion

GUFT replaces classical singularities with finite DEQF cores, yields modified Hawking spectra, and predicts observable end-states. Upcoming gamma-ray and GW observatories can test these predictions, providing a decisive probe of GUFT.

References

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